A LABORATORY STUDY OF THE EFFECTS OF OVEN CURING LOOSE AND COMPACTED ASPHALTIC CONCRETE MIXTURES

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A LABORATORY STUDY OF THE EFFECTS OF OVEN CURING LOOSE AND COMPACTED ASPHALTIC CONCRETE MIXTURES

Introduction

Laboratory evaluations of asphaltic concrete mixtures are often used to measure the physical characteristics of paving materials. Laboratory materials evaluations and mix designs are considered a necessary part of the over-all job of building quality pavements. Since the results of such tests and evaluations may be affected to a measurable degree by certain aspects of the different testing procedures used, it is valuable and often necessary to know the extent of the effects of such factors.

The test procedures of some state agencies require that hot-mix asphalt-aggregate mixtures designed and prepared in the laboratory be oven cured overnight at, say, 140°F in the loose state prior to molding and testing; while similar procedures followed by other agencies allow such mixtures to be mixed and molded without delay.

It was the purpose of this study to measure the effect of oven curing on loose and compacted mixtures of asphaltic concrete made from dense graded aggregates and penetration grade asphalt cements.

Materials

There were three grades of asphalt cement from a single source used in the study. The grades included were 60-70, 85-100, and 120-150 penetration. The three dense graded aggregates studied included an all rounded siliceous gravel of low absorption, a crushed quartzite-limestone mixture of medium absorption and a crushed limestone of high absorption. The quartzite-limestone aggregate will be referred to as quartzite hereafter in this report. The gradings of aggregates used are shown in Table 1 and laboratory values of the physical characteristics of these same materials are shown in Table 2.

As may be seen from Table 1 gradings of these materials are almost identical; however, textural characteristics and absorption capacity were materially different. Aggregates of different types were purposely chosen for inclusion in the study so tests could be made to see whether or not oven curing effected different magnitudes of change for absorptive and textured aggregates as opposed to smooth dense aggregates.

TABLE 1

Grading Analyses of Aggregates Used
(Percent Retained Basis)

Sieve Size	Gravel Conc. Gravel 48% Conc. Sand 32% Queen City Sand 20%	Quartzite Quartzite 48% Coarse Screenings 16% Fine Screenings 36%	Limestone Limestone 100%	Averages
5/8-inch	0	0	0	0
1/2-inch	4.1	4.0	4.1	4.1
3/8-inch	24.9	24.0	23.3	24.1
No. 4	47.5	48.0	47.5	47.7
No. 8	54.0	52.0	53.8	53.3
No. 16	58.7	57.3	59.0	58.3
No. 30	64.4	64.0	64.9	64.4
No. 50	76.6	75.5	79.1	77.1
No. 100	89.5	90.4	90.4	90.1
No. 200	98.3	97.3	96.7	97.4
Passing No. 200	1.7	2.7	3.3	2.6

TABLE 2

Physical Properties of Aggregates and Asphalt Demand

Physical Property	Rounded Gravel	Crushed Quartzite	Crushed Limestone
Surface Area, sq. ft./lb.	29	31	29
Sand Equivalent	72	50	45
Apparent Sp. Gr.	2.65	2.80	2.71
Asphalt Content, % by CKE - 60-70	4.5	5.3	7.4
85-100	4.1	5.0	7.3
120-150	3.9	4.8	7.2

Reference to Table 2 reveals aggregate combination of essentially equal surface area per unit weight of material. Although the sand equivalent for the three materials covered the range 72 to 45, all three aggregates are considered to be of good quality as determined by this test. Asphalt requirements as determined by the California centrifuge kerosene equivalent, CKE, are also listed in Table 2. The values listed for the gravel and the quartzite are reliable and might be used in job mixed formulations with little if any adjustment; however for a highly absorptive material such as the limestone, CKE values are usually high by as much as 0.50 to 0.75 percentage points. This is clearly evident in Table 5.

Tables 3, 4, and 5 list laboratory data on mixes made with three different aggregates and three grades of asphalt cement. Standard or control batches were prepared and evaluated for each of the thirty-six different designs investigated. These standard batches were prepared from the selected materials in accordance with procedure outlined in Texas Highway Department Construction Bulletin C-14 and tested by methods listed in the Manual of Testing Procedures published by THD. The reader is referred to Table 3. The first line of data for each grade of asphalt cement used with this aggregate is headed at the left with the term "standard." By reading horizontally to the right values of bulk specific gravity, Hveem stability and Hveem cohesion may be seen for each of the four asphalt contents used. Similarly "standards" for the other grades of asphalt appear in the center and lower third on this same table.

Sufficient additional asphalt-aggregate mixture was prepared for studying the effect of oven curing for different periods of time. For each curing period of 5, 15, 20, and 30 hours duplicate batches were prepared at each asphalt content and for each grade of asphalt used. One of these batches was molded, directly after mixing, into laboratory test specimens four inches in diameter by two inches in height and was then cured, while the companion batch was cured loose and then molded into test specimens. All curing for the entire study was carried out in force draft ovens controlled at 140 $\pm$ 5°F.

A total of 132 duplicate batches were thus prepared, oven cured, and tested in addition to the 36 control or standard batches. Laboratory test values for the 168 batches are shown in Tables 3, 4, and 5.

Table 3 deals with data taken from asphaltic concrete mixtures prepared from rounded siliceous gravel and sand. The series of blends made from this aggregate showed no measurable difference in stability due to oven curing, whether the mixes were cured loose or compacted. If the cohesiometer

TABLE 3

Effects of Curing on Bulk Specific Gravity, Stability and Cohesion of Mixtures with Rounded Siliceous Gravel Aggregate

Asphalt Content, %

Asphalt Grade	Curing Time-Condition	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.
		4.25			4.50			4.75			5.00		
60-70	Standard	2.31	43	84	2.32	46	123	2.34	46	131	2.34	43	109
60-70	5 hr. Molded	2.31	43	113	2.34	44	156	2.34	44	148	2.34	42	181
60-70	Loose	2.31	43	106	2.32	48	123	2.32	42	138	2.34	42	185
60-70	15 hr. Molded	2.33	45	151	2.32	44	170	2.33	44	175	2.36	43	218
60-70	Loose	2.32	45	123	2.33	43	167	2.34	48	188	2.34	42	199
60-70	20 hr. Molded	2.33	47	100	2.36	50	141	2.35	46	139	2.34	45	156
60-70	Loose	2.32	42	95	2.34	44	121	2.34	42	153	2.36	42	181
60-70	30 hr. Molded	2.33	40	130	2.33	44	147	2.35	44	119			
60-70	Loose	2.34	44	174	2.34	45	163	2.35	42	148			
		3.75			4.00			4.25			4.50		
85-100	Standard	2.27	38	61	2.27	40	75	2.29	41	88	2.31	39	82
85-100	5 hr. Molded	2.32	47	104	2.30	41	91	2.32	41	89	2.32	36	49
85-100	Loose	2.30	37	96	2.30	42	72	2.30	38	44	2.31	37	55
85-100	15 hr. Molded	2.29	37	90	2.30	39	100	2.30	42	104	2.31	37	105
85-100	Loose	2.31	41	88	2.32	41	113	2.33	44	103	2.34	42	120
85-100	20 hr. Molded	2.30	41	93	2.31	45	100	2.32	42	65	2.34	46	79
85-100	Loose	2.30	43	86	2.30	40	109	2.31	38	79	2.32	38	85
85-100	30 hr. Molded	2.34	40	90	2.34	42	99	2.35	46	122	2.34	43	103
85-100	Loose	2.35	43	143	2.32	40	107	2.32	44	131	2.35	41	117
		4.25			4.75			5.25			5.75		
120-150	Standard	2.30	34	44	2.33	37	64	2.34	42	94	2.34	33	102
120-150	5 hr. Molded	2.33	41	29	2.33	37	45	2.34	33	50	2.34	28	63
120-150	Loose	2.31	39	39	2.32	34	51	2.34	36	57	2.32	29	65
120-150	15 hr. Molded	2.30	36	49	2.34	48	64	2.33	38	63	2.34	34	95
120-150	Loose	2.32	38	57	2.33	37	63	2.35	38	114	2.35	27	93
120-150	20 hr. Molded	2.33	37	32	2.36	37	53	2.35	31	77	2.36	22	96
120-150	Loose	2.31	37	34	2.34	37	55	2.35	28	103	2.34	22	97
120-150	30 hr. Molded	2.33	39	67	2.34	40	71	2.33	32	61	2.34	27	77
120-150	Loose	2.31	39	50	2.32	40	55	2.34	32	67	2.34	28	104

TABLE 4

Effects of Curing on Bulk Specific Gravity, Stability and Cohesion of Mixture with Crushed Quartzite Aggregate

		Asphalt Content, %											
		3.80			4.30			4.80			5.30		
Asphalt Grade	Curing Time-Condition	Bulk Sp.Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp.Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.
	Standard	2.41	56	261	2.46	61	294	2.45	56	284	2.46	56	334
	5 hr. Molded	2.45	64	424	2.47	61	454	2.50	55	536	2.49	45	329
	Loose	2.43	60	383	2.44	61	446	2.48	52	473	2.48	39	389
	15 hr. Molded	2.41	57	268	2.44	57	335	2.48	59	439	2.48	51	486
60-70	Loose	2.43	59	351	2.48	60	508	2.48	62	422	2.49	43	385
	20 hr. Molded	2.43	60	399	2.43	62	490	2.48	58	547	2.48	44	479
	Loose	2.45	59	240	2.45	61	410	2.47	58	315	2.48	32	260
	30 hr. Molded	2.42	62	250	2.45	65	293	2.48	57	384	2.48	27	329
	Loose	2.43	59	229	2.44	67	210	2.48	54	339	2.48	30	291
		4.00			4.50			5.00			5.50		
	Standard	2.44	56	179	2.44	62	184	2.47	60	281	2.47	49	227
	5 hr. Molded	2.44	58	222	2.47	57	329	2.48	41	326	2.49	22	288
	Loose	2.43	51	170	2.44	58	189	2.47	58	339	2.48	16	261
	15 hr. Molded	2.46	57	205	2.48	56	256	2.48	59	223	2.49	32	184
85-100	Loose	2.45	60	225	2.45	59	251	2.44	59	225	2.47	37	237
	20 hr. Molded	2.42	58	198	2.44	57	226	2.47	52	316	2.49	26	263
	Loose	2.44	56	202	2.46	52	144	2.47	50	245	2.47	14	239
	30 hr. Molded	2.45	57	201	2.48	60	301	2.49	44	295	2.49	10	271
	Loose	2.44	61	255	2.46	60	256	2.49	53	302	2.48	15	224
		3.75			4.25			4.75			5.25		
	Standard	2.45	62	154	2.44	60	136	2.48	56	241	2.46	51	216
	5 hr. Molded	2.46	54	161	2.47	55	175	2.48	49	214	2.49	49	201
	Loose	2.45	55	133	2.46	56	162	2.47	53	157	2.49	42	209
	15 hr. Molded	2.44	55	120	2.45	55	113	2.48	52	259	2.49	53	283
120-150	Loose	2.43	56	99	2.45	60	102	2.49	52	236	2.49	42	262
	20 hr. Molded	2.43	58	134	2.47	61	177	2.47	59	191	2.50	40	256
	Loose	2.44	57	122	2.47	56	153	2.48	59	145	2.49	24	220
	30 hr. Molded	2.45	58	143	2.45	54	159	2.47	55	125	2.49	40	203
	Loose	2.44	57	152	2.47	54	150	2.47	56	112	2.48	44	219

TABLE 5

Effects of Curing on Bulk Specific Gravity, Stability and Cohesion of Mixtures with Crushed Limestone Aggregate

		Asphalt Content, %											
		5.50			6.00			6.50			7.00		
Asphalt Grade	Curing Time-Condition	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.	Bulk Sp. Gr.	Hveem Stab.	Hveem Coh.
	Standard	2.29	62	265	2.31	61	264	2.32	52	318	2.32	23	218
60-70	5 hr. Molded	2.33	68	490	2.35	54	490	2.34	29	333	2.33	18	347
	Loose	2.32	70	513	2.34	52	550	2.33	24	394	2.33	16	335
	15 hr. Molded	2.32	64	537	2.34	45	546	2.34	38	371	2.34	22	338
	Loose	2.31	72	444	2.34	56	497	2.32	43	383	2.32	19	370
	20 hr. Molded	2.30	66	267	2.31	64	337	2.35	29	322	2.33	39	337
	Loose	2.29	65	283	2.32	61	295	2.33	22	315	2.33	32	337
		5.50			6.00			6.50			7.00		
	Standard	2.30	67	364	2.31	64	360	2.32	62	391	2.32	50	398
	5 hr. Molded	2.34	67	419	2.34	48	464	2.34	36	441	2.34	26	393
	Loose	2.33	65	403	2.34	49	464	2.34	35	439	2.33	—	312
85-100	15 hr. Molded	2.30	59	337	2.31	59	445	2.33	54	328	2.33	32	324
	Loose	2.30	62	354	2.30	62	324	2.32	51	340	2.32	42	312
	20 hr. Molded	2.29	62	246	2.31	59	353	2.33	50	332	2.33	33	265
	Loose	2.30	68	320	2.32	61	363	2.32	46	345	2.32	25	298
		5.50			6.00			6.50			7.00		
	Standard	2.28	59	219	2.29	64	209	2.32	58	343	2.32	31	277
	5 hr. Molded	2.31	68	286	2.33	59	373	2.35	28	322	2.33	24	258
	Loose	2.25	63	209	2.26	67	219	2.27	65	187	2.30	58	312
120-150	15 hr. Molded	2.32	60	414	2.33	54	496	2.34	35	370	2.34	21	321
	Loose	2.33	64	308	2.34	50	402	2.33	36	300	2.33	14	281
	20 hr. Molded	2.34	62	367	2.34	51	318	2.35	17	335	2.34	14	286
	Loose	2.33	58	330	2.34	49	333	2.34	11	300	2.33	17	275

values of the standard or control batches are compared to those of the cured batches a slight increase for the cured batches is noted; however, varying the time of curing from 5 to 30 hours appeared to make little difference. Whether the batches in question were cured loose or compacted seemed to make no definite difference. It is apparent that stability values are about ten percent higher for the harder asphalt. This effect of binder viscosity on specimen stability was in evidence only for the all rounded aggregate. Knowledge of this factor may be of value in cases where such materials must be used if stability values are critical.

Table 4 lists data on asphaltic concrete mixtures made from an all crushed quartzite of medium absorption. Stability of these mixes was not materially affected by curing in either the loose or the compacted state. There was, however, an increase in the cohesiometer value that may be attributed to oven curing and the increase was greater for the harder asphalt. It did not appear to matter whether the mix was cured loose or molded as may be seen from the data.

Table 5 lists the data on blends of asphalt and crushed limestone. The trends observed for the crushed quartzite of Table 4 are essentially repeated for these data.

Laboratory measurements were also made on the relative density of the compacted specimens to see if curing in the loose state would change the compaction characteristics of the mix. This phase of the search was made only on the rounded aggregate since it was reasoned that if any change occurred it would take place with this material. As may be seen from Table 6 no real difference was revealed.

Tables A, B, and C of the Appendix list the vacuum saturation specific gravities of the mixes cured in the loose state. These values were determined after the method of Rice on the loose mix and show the effects of asphalt absorption on the computed theoretical specific gravity. Reference is also made to the bulk specific gravities of the molded specimens. These are found in Tables 3, 4, and 5. No significant differences are revealed in any of these data.

To determine whether or not there was a measurable and significant difference in the viscosity of the binder in these mixes after they were subjected to different amounts of oven curing in both the loose and compacted state; extractions and Abson recoveries were performed on mixtures containing the highest asphalt content. The recovered asphalt was checked

TABLE 6

Relative Density Values Showing Effect of Asphalt Grade, Curing Condition and Asphalt Content on a Rounded Siliceous Gravel Aggregate

Asphalt Grade	Curing - 140°F Time	Condition	Asphalt Content, % 4.25	4.50	4.75	5.00
	Standard		94.0	95.0	98.0	
	5 hr.	Loose	94.6	95.9	94.9	97.3
		Molded	94.7	96.5	95.9	97.3
	15 hr.	Loose	94.2	95.5	96.4	96.4
60-70		Molded	94.4	94.9	96.0	97.0
	20 hr.	Loose	95.1	95.5	95.5	96.1
		Molded	95.2	96.1	96.0	95.6
	30 hr.	Loose	96.5	94.7	94.5	
		Molded	94.9	94.3	94.6	
			3.75	4.00	4.25	4.50
	Standard		90.8	91.2	93.4	96.7
	5 hr.	Loose	92.2	93.5	92.0	95.3
		Molded	93.2	93.3	92.9	95.6
	15 hr.	Loose	91.3	94.5	94.1	95.3
85-100		Molded	94.5	93.6	93.2	94.3
	20 hr.	Loose	92.0	92.1	93.2	93.3
		Molded	92.4	92.8	93.3	94.1
	30 hr.	Loose	95.6	94.1	93.9	95.1
		Molded	95.5	95.2	94.8	94.8
			4.25	4.75	5.25	5.75
	Standard		----	----	----	----
	5 hr.	Loose	93.3	94.2	97.4	95.2
		Molded	94.2	94.8	97.5	96.0
	15 hr.	Loose	93.9	95.1	97.2	97.3
120-150		Molded	92.9	95.7	95.1	96.9
	20 hr.	Loose	94.3	96.7	97.2	98.7
		Molded	95.0	97.1	96.9	99.2
	30 hr.	Loose	94.4	95.5	96.7	96.7
		Molded	95.1	96.1	96.6	96.5

for changes in standard penetration and absolute viscosity. Absolute viscosity values were obtained with the sliding plate microfilm viscometer and reported in mega poises at 5×10^{-2} sec^{-1}. These data included in the Appendix as Table D are incomplete and inconclusive. It is, however, evident that oven curing at 140°F generally increased the absolute viscosity of the binder and of course decreased the standard penetration.

Conclusions and Recommendations

Based on the materials and conditions of tests encountered in this study the following conclusions appear to be warranted.

1. Oven curing of both the loose and molded asphalt-aggregate mixtures for time intervals up to 30 hours did not materially affect the Hveem stability. This held true for all three aggregates studied.

2. The Hveem cohesion values were generally increased with increasing curing time for mixes made with the rounded gravel and the two harder asphalt cements. For the crushed limestone the cohesiometer value appeared to peak at about 15 hours of curing and this peaking was not relegated to state of compaction, that is, it did not appear to matter whether the mix was loose or molded. The quartzite blends presented no definite patterns in cohesiometer values. As expected, cohesiometer values decreased in all mixes with decreasing viscosity of asphalt cement.

3. Oven curing of the rounded gravel mixtures for periods of time up to 30 hours did not appear to affect densification effected during molding of the test specimens.

4. Vacuum saturation specific gravities of the loose mixes were unaffected by oven curing of the loose mixes for periods of time up to 30 hours.

5. Data on the standard penetration and absolute viscosity of the asphalt cement recovered from the various mixes revealed an expected general increase in viscosity with exposure to heat and a somewhat greater increase in viscosity with exposure to heat and air, if it is assumed that the loose mix was more exposed to air than the molded specimen duplicating the loose sample. In certain instances measured viscosities of cement recovered from mixtures cured in the loose state were lower than that for the molded specimen. Such differences may be attributed to differences in the test procedure train.

It is recommended that this study be extended possibly in coordinated segments by graduate students to cover at least two additional sources of asphalt cement. The selected asphalt used in the study reported is considered to have better than average resistance to oxidation from exposure to air and heat. An asphalt known to be fairly susceptible to the action of heat and air should be studied in the manner reported. An asphalt processed differently should also be included. An asphalt produced by solvent refining is suggested.

APPENDIX

TABLE A

Effect of Curing Time on Vacuum Saturation-Specific Gravity of Loose Asphalt-Aggregate Mixtures

Rounded Siliceous Gravel

	60-70 Asphalt Content				85-100 Asphalt Content				120-150 Asphalt Content			
	4.25	4.5	4.75	5.0	3.75	4.00	4.25	4.50	4.25	4.75	5.25	5.75
Theoretical	2.481	2.471	2.461	2.451	2.500	2.491	2.481	2.472	2.480	2.462	2.444	2.426
Standard	2.455	2.444	2.430*	2.411*	2.500	2.501	2.480	2.417	----	----	----	----
5 Hour	2.444	2.425	2.441	2.407	2.489	2.463	2.499	2.431	2.472	2.410	2.401	2.438
15 Hour	2.464	2.442	2.429	2.431	2.532	2.460	2.458	2.455	2.470	2.447	2.432	2.412
20 Hour	2.443	2.451	2.447	2.450	2.432	2.496	2.458	2.455	2.450	2.423	2.421	2.375
30 Hour	2.459	2.474	2.484	-----	2.445	2.460	2.477	-----	2.449	2.437	2.414	2.422

*Data obtained by interpolation or cross plots.

TABLE B

Effect of Curing Time on Vacuum Saturation-Specific Gravity of Loose Asphalt-Aggregate Mixture

Crushed Quartzite

	60-70 Asphalt Content				85-100 Asphalt Content				120-150 Asphalt Content			
	3.80	4.30	4.80	5.30	4.0	4.5	5.00	5.5	3.75	4.25	4.75	5.25
Theoretical	2.625	2.604	2.583	2.564	2.617	2.596	2.575	2.555	2.627	2.606	2.584	2.564
Standard	2.602*	2.595	2.579	2.499	2.583	2.550*	2.529	2.512	----	----	----	----
5 Hour	2.596	2.579	2.570	2.535	2.590	2.584	2.577	2.526	2.581	2.569	2.533	2.546
15 Hour	2.617	2.575	2.541	2.530	2.600	2.490	2.559	2.527	2.624	2.532	2.533	2.498
20 Hour	2.584	2.552	2.552	2.536	2.603	2.537	2.574	2.531	2.615	2.561	2.505	2.507
30 Hour	-----	2.574	2.568	2.502	2.566	2.544	2.538	2.515	2.562	2.560	2.481	2.505*

*Data obtained by interpolation or cross plots.

TABLE C

Effect of Curing Time on Vacuum Saturation-Specific Gravity of Loose Asphalt-aggregate Mixture

Crushed Limestone

	60-70 Asphalt Content				85-100 Asphalt Content				120-150 Asphalt Content			
	5.5	6.0	6.5	7.0	5.5	6.0	6.5	7.0	5.5	6.0	6.5	7.0
Theoretical	2.485	2.466	2.448	2.430	2.485	2.466	2.448	2.430	2.485	2.466	2.448	2.430
Standard	2.414	2.391	2.360	2.334	2.406	2.382	2.377	2.360	2.406	2.387	2.376	2.376
5 Hour	2.399	2.392	2.364	2.326	2.403	2.382	2.344	2.322	2.360	2.337	2.344	-----
15 Hour	2.377	2.362	2.380	2.343	2.376	2.362	2.340	2.359	2.417	2.380	2.346	2.354
20 Hour	2.384	2.369	2.350	2.319	2.406	2.385	2.369	2.341	2.430	2.388	2.362	2.347

TABLE D

Consistency Values of Recovered Asphalt Showing Effects of Curing Time
Test Temperature of 77°F and Viscosity in Megapoise

	Curing		Siliceous Gravel		Crushed Quartzite		Crushed Limestone	
Asphalt	Time	Condition	Pen.	Vis.	Pen.	Vis.	Pen.	Vis.
	Original		59	3.60	63	--	61	--
	Standard		51	4.45	50	5.80	45	5.64
	5 Hr.	Molded	43	7.80	36	9.61	36	11.30
		Loose	42	6.45	40	6.00	38	12.60
60 - 70	15 Hr.	Molded	39	9.90	43	8.90	62	7.63
		Loose	42	7.80	36	--	41	12.60
	20 Hr.	Molded	36	--	44	6.30	31	14.70
		Loose	42	7.00	43	6.70	34	12.10
	30 Hr.	Molded	64	3.50	38	10.2	--	--
		Loose	62	4.80	34	11.8	--	--
	Original		86	1.50	90	2.24	--	2.24
	Standard		74	2.45	59	3.75	46	5.42
	5 Hr.	Molded	60	2.70	57	4.35	55	3.99
		Loose	66	2.40	62	3.40	50	5.21
85 - 100	15 Hr.	Molded	59	3.25	50	6.00	53	5.03
		Loose	60	3.30	44	8.40	53	4.81
	20 Hr.	Molded	65	3.10	60	4.60	54	5.44
		Loose	64	3.20	67	--	52	5.44
	30 Hr.	Molded	54	5.00	73	3.94	--	--
		Loose	64	3.50	63	4.92	--	--
	Original		--	0.88	--	0.88	107	0.88
	Standard		--	--	--	--	73	1.48
	5 Hr.	Molded	--	--	95	0.95	87	1.26
		Loose	--	--	81	1.13	72	1.96
120 - 150	15 Hr.	Molded	68	1.97	--	--	80	1.60
		Loose	84	2.40	68	2.20	--	--
	20 Hr.	Molded	--	--	73	1.59	76	1.72
		Loose	--	--	74	1.74	66	2.11
	30 Hr.	Molded	72	1.46	84	1.37	--	--
		Loose	63	1.95	73	1.77	--	--

PUBLICATIONS

Project 2-8-57-3
Road Tests on Hot-Mix Asphaltic Concrete

1. Research Report 3-1, "A Laboratory Study of the Operator Variable on Molding Procedure and Mix Design Variations in Hot-Mix Asphaltic Concrete" by Bob M. Gallaway and R. A. Jimenez.

2. Research Report 3-2, "A Laboratory Study of Oven Curing Loose and Compacted Asphaltic Concrete Mixtures" by R. A. Jimenez and Bob M. Gallaway.